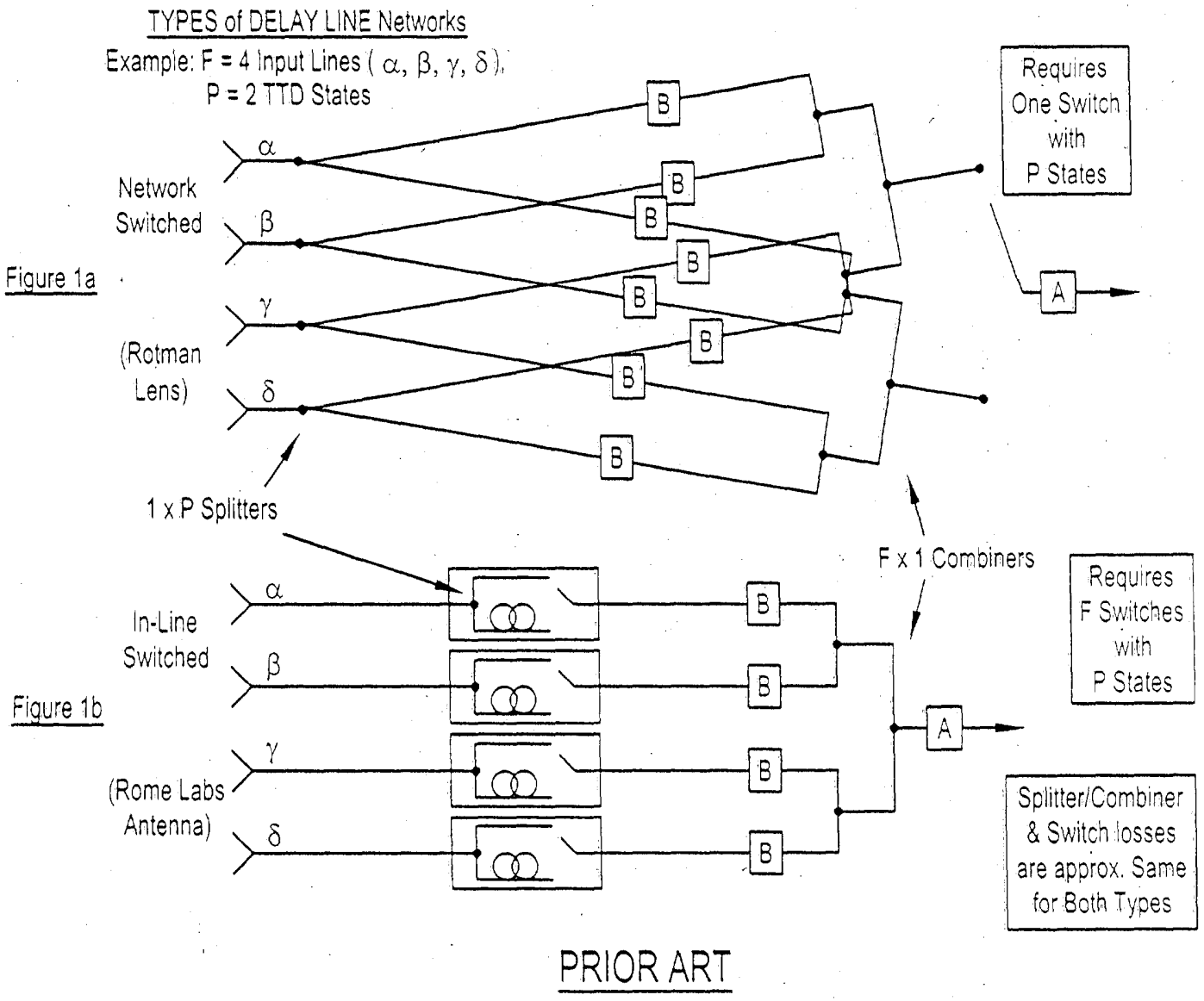

Figure 1a

Figure 1b

PRIOR ART

EV 258281415 US

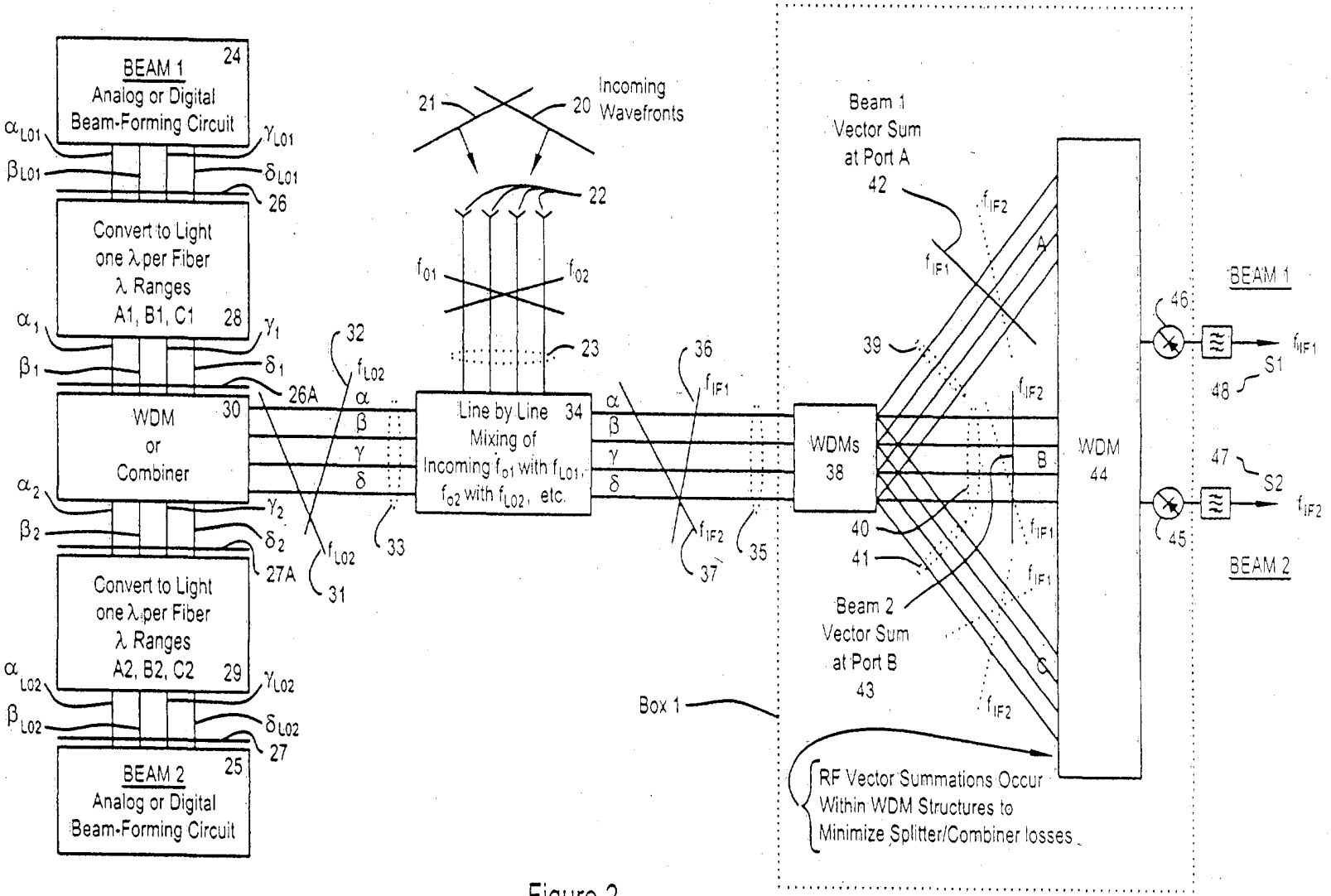
BEAM 1
Analog or Digital
Beam-Forming Circuit
24
Convert to Light
one λ per Fiber
λ Ranges
A1, B1, C1
28
WDM
or
Combiner
30
Convert to Light
one λ per Fiber
λ Ranges
A2, B2, C2
29
BEAM 2
Analog or Digital
Beam-Forming Circuit
25
Incoming
Wavefronts
20
21
22
23
Line by Line
Mixing of
Incoming f_{O1} with f_{LO1},
f_{O2} with f_{LO2}, etc.
34
WDMs
38
Beam 1
Vector Sum
at Port A
42
Beam 2
Vector Sum
at Port B
43
WDM
44
BEAM 1
BEAM 2
S1
S2
Box 1
RF Vector Summations Occur
Within WDM Structures to
Minimize Splitter/Combiner losses

Figure 2

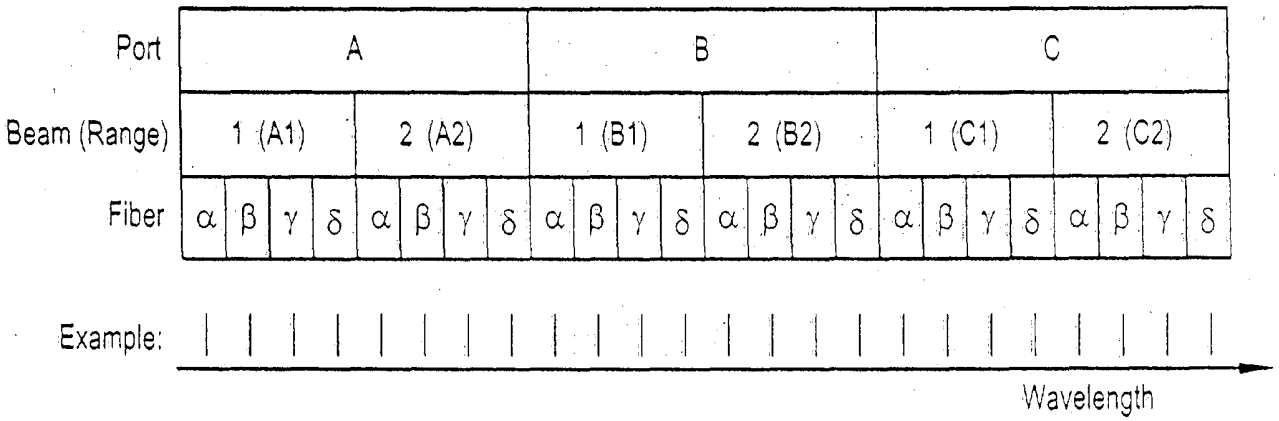
Port
A
B
C
Beam (Range)
1 (A1)
2 (A2)
1 (B1)
2 (B2)
1 (C1)
2 (C2)
Fiber
α β γ δ α β γ δ α β γ δ α β γ δ α β γ δ α β γ δ
Example:
Wavelength

Figure 3a

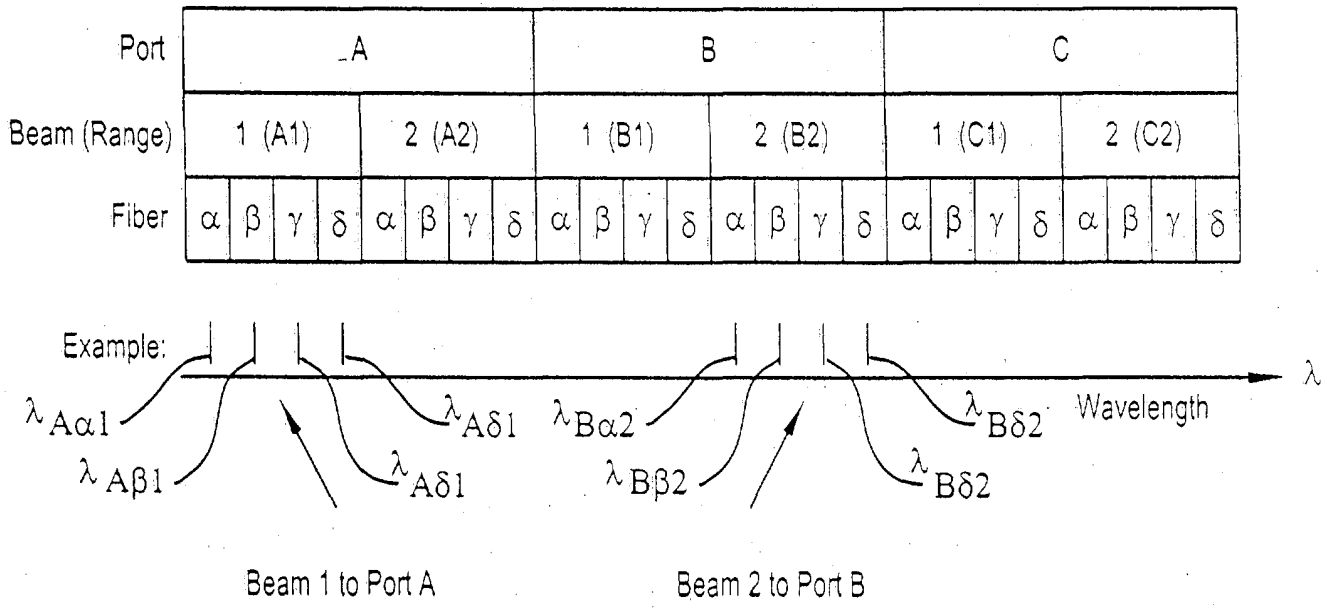
Port
A
B
C
Beam (Range)
1 (A1)
2 (A2)
1 (B1)
2 (B2)
1 (C1)
2 (C2)
Fiber
α β γ δ α β γ δ α β γ δ α β γ δ α β γ δ α β γ δ
Example:
λ
Wavelength
λAα1
λAβ1
λAδ1
λAδ1
λBα2
λBβ2
λBδ2
λBδ2
Beam 1 to Port A
Beam 2 to Port B

Figure 3b

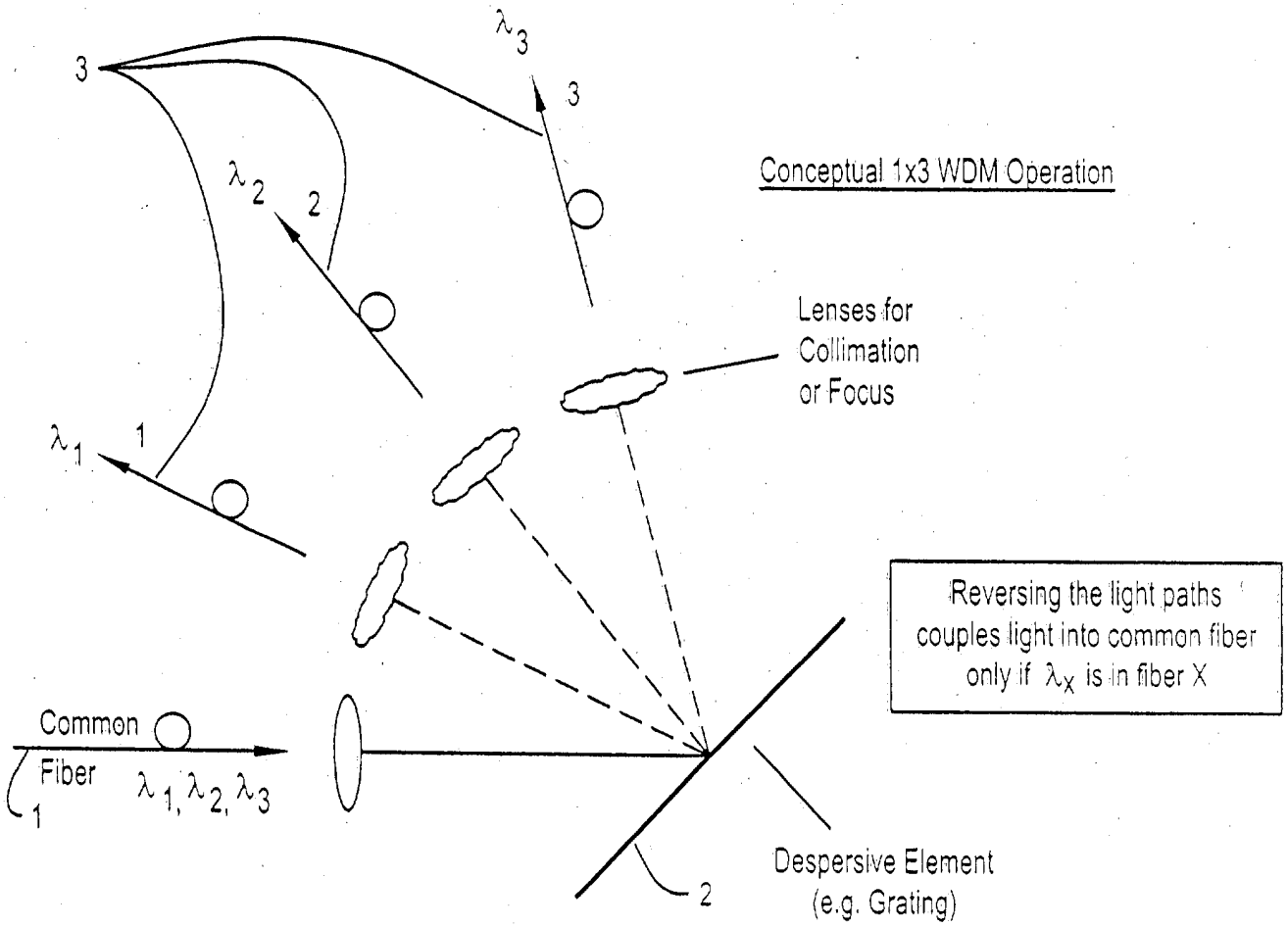
Conceptual 1x3 WDM Operation
Lenses for Collimation or Focus
Reversing the light paths couples light into common fiber only if λ_X is in fiber X
Common Fiber
$\lambda_1, \lambda_2, \lambda_3$
Despersive Element (e.g. Grating)
λ_1
λ_2
λ_3
1
2
3

Figure 4

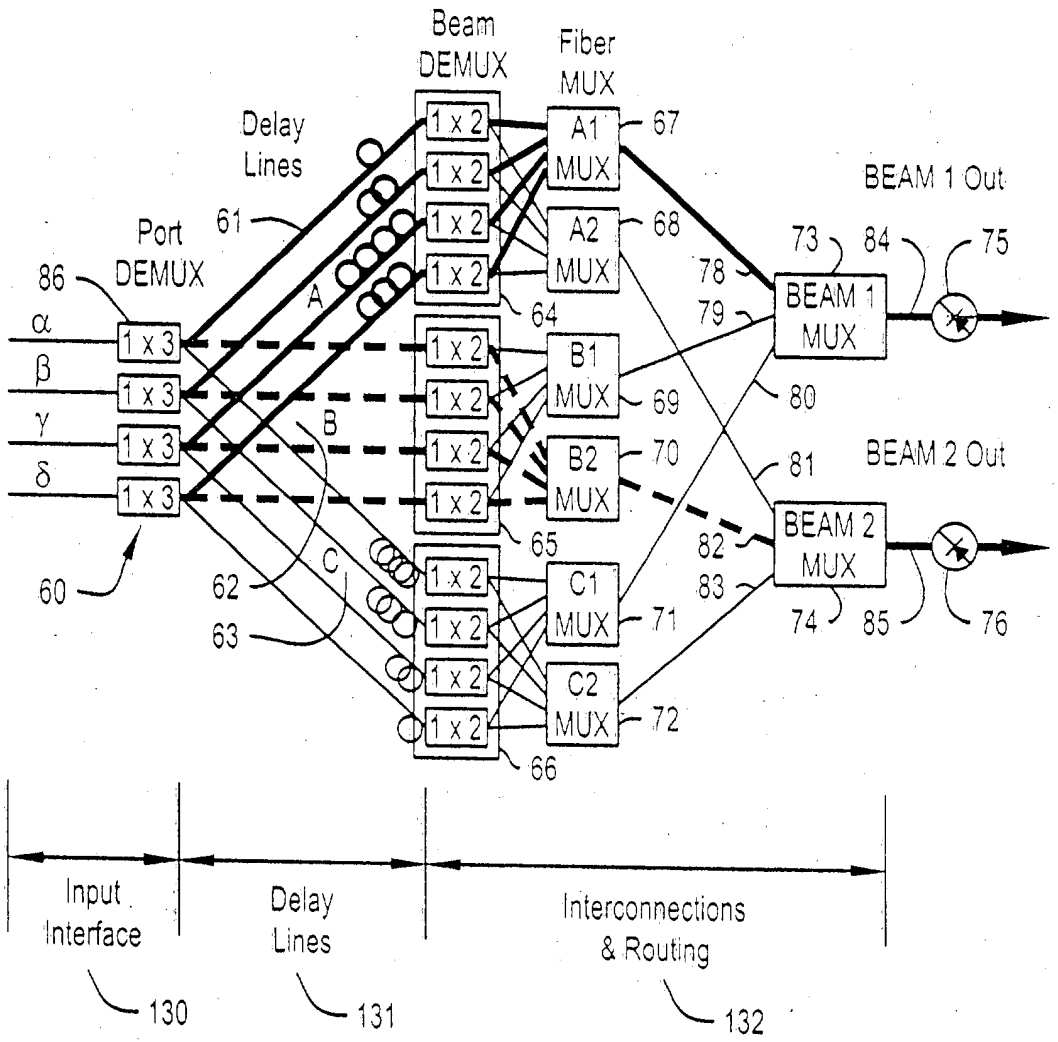
Beam
DEMUX
Fiber
MUX
Delay
Lines
61
Port
DEMUX
86
α
β
γ
δ
1 x 3
1 x 2
A
B
C
60
62
63
64
65
66
A1
MUX
A2
MUX
B1
MUX
B2
MUX
C1
MUX
C2
MUX
67
68
69
70
71
72
BEAM 1 Out
BEAM 2 Out
BEAM 1
MUX
BEAM 2
MUX
73
84
75
78
79
80
81
82
83
74
85
76
Input
Interface
130
Delay
Lines
131
Interconnections
& Routing
132

Figure 5

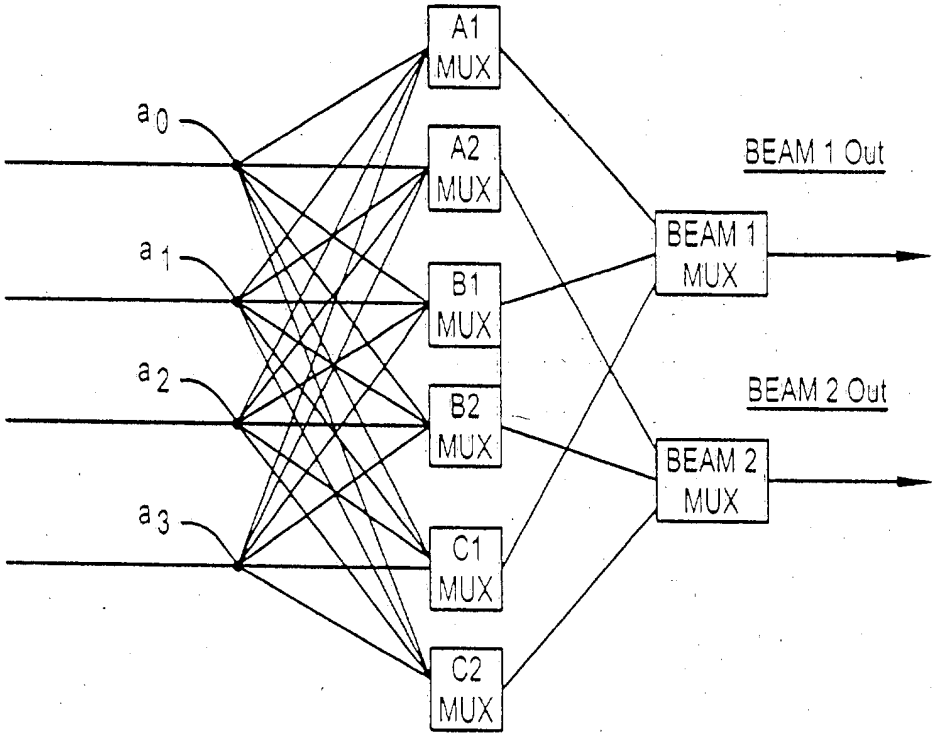
a0
a1
a2
a3
A1 MUX
A2 MUX
B1 MUX
B2 MUX
C1 MUX
C2 MUX
BEAM 1 MUX
BEAM 2 MUX
BEAM 1 Out
BEAM 2 Out

Figure 6

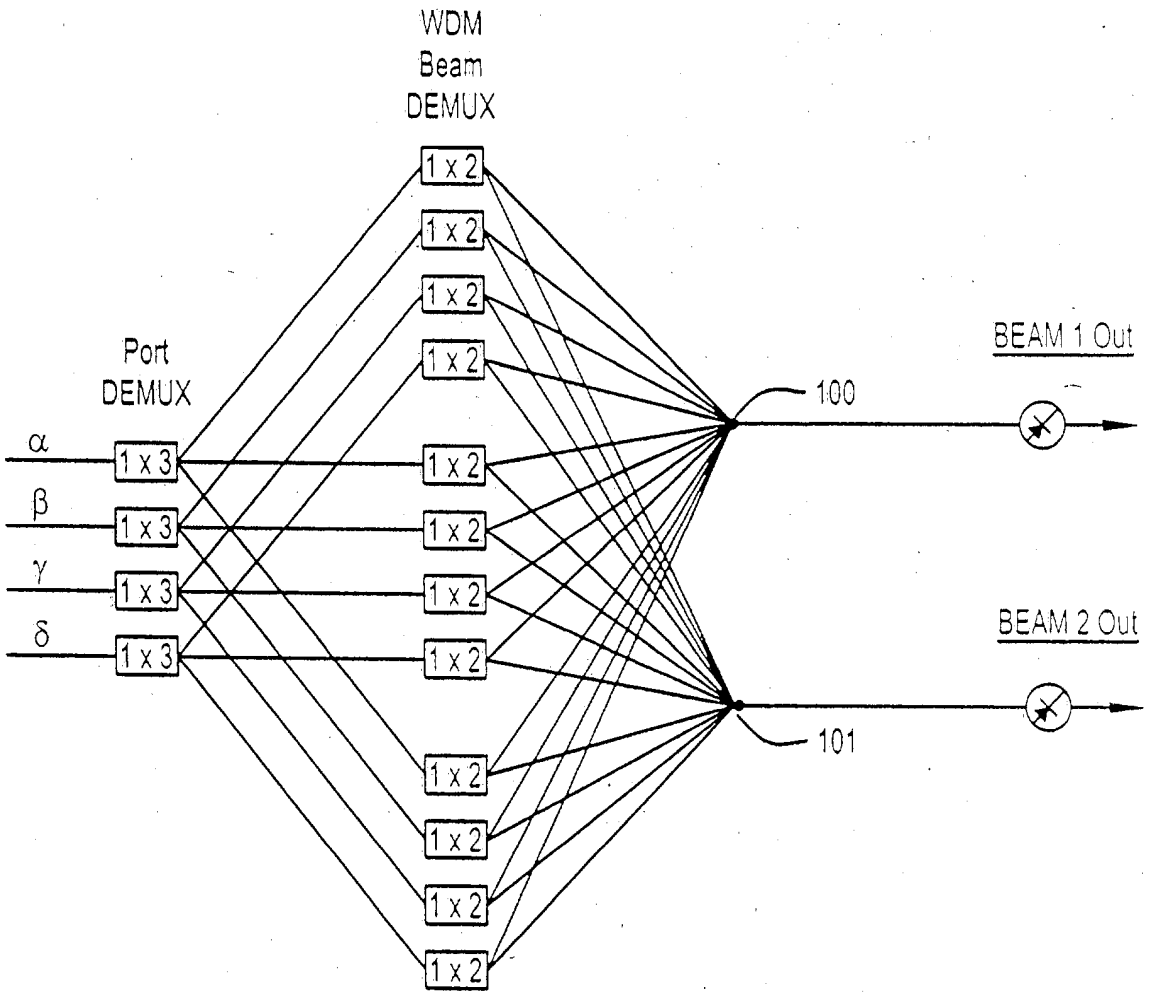
WDM
Beam
DEMUX
Port
DEMUX
α
β
γ
δ
1 x 3
1 x 3
1 x 3
1 x 3
1 x 2
1 x 2
1 x 2
1 x 2
1 x 2
1 x 2
1 x 2
1 x 2
1 x 2
1 x 2
1 x 2
1 x 2
100
101
BEAM 1 Out
BEAM 2 Out

Figure 7

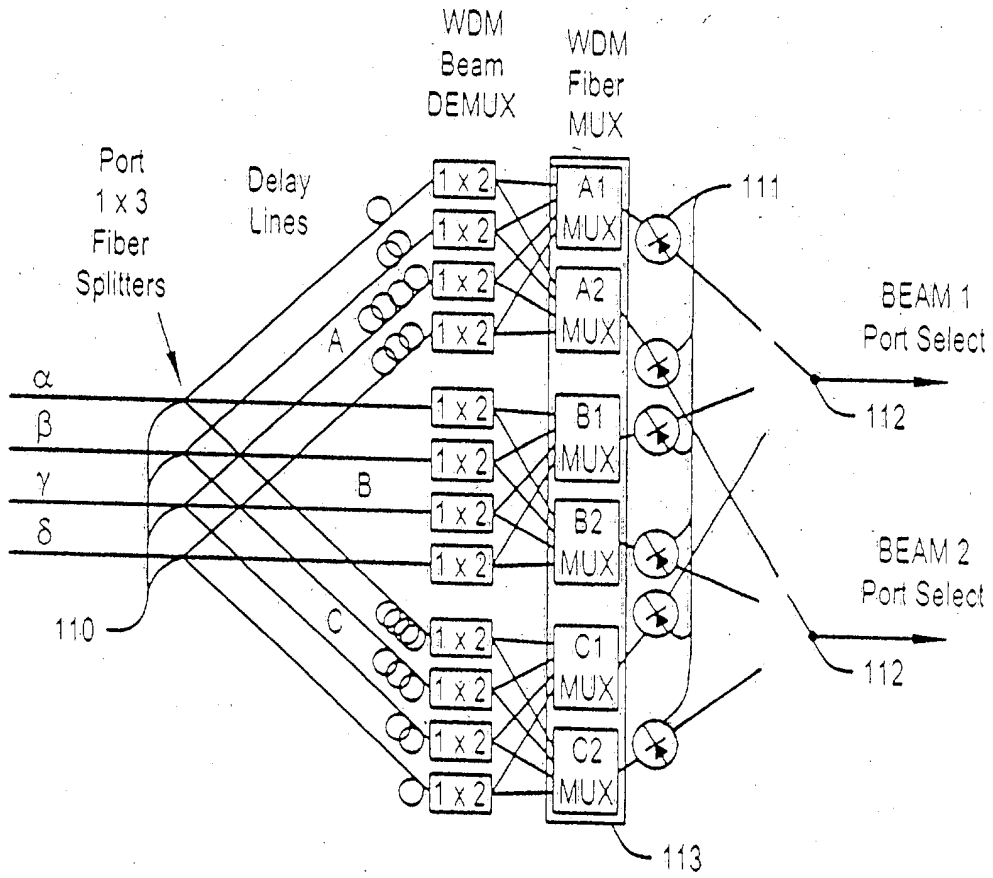
WDM
Beam
DEMUX
WDM
Fiber
MUX
Port
1 x 3
Fiber
Splitters
Delay
Lines
1 x 2
A1
MUX
A2
MUX
B1
MUX
B2
MUX
C1
MUX
C2
MUX
111
BEAM 1
Port Select
112
BEAM 2
Port Select
112
A
B
C
α
β
γ
δ
110
113

Figure 8

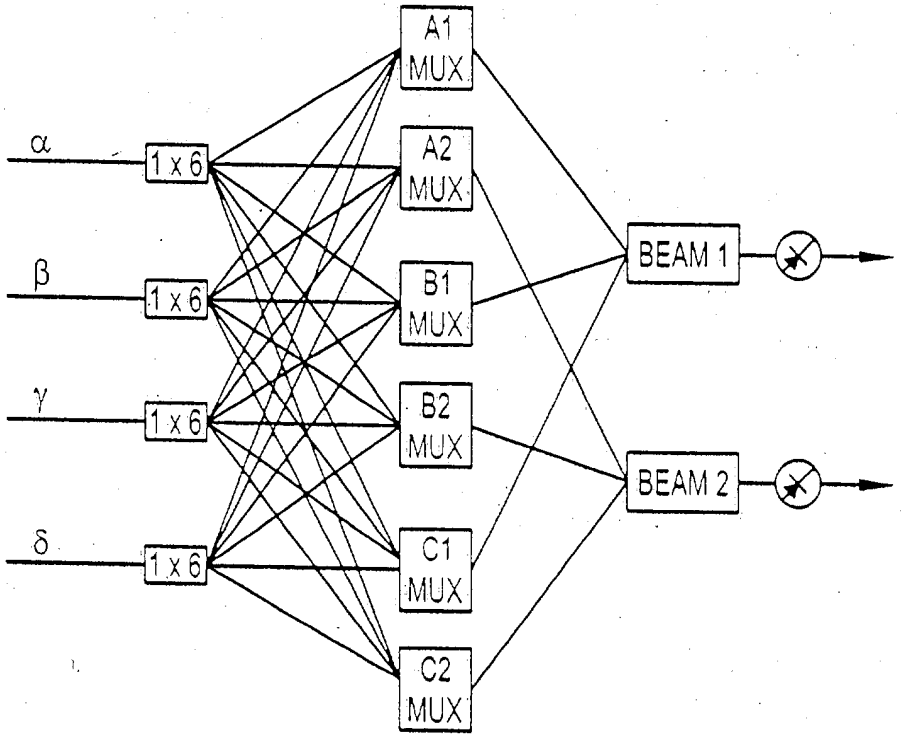
α
β
γ
δ
1 x 6
1 x 6
1 x 6
1 x 6
A1 MUX
A2 MUX
B1 MUX
B2 MUX
C1 MUX
C2 MUX
BEAM 1
BEAM 2

Figure 9

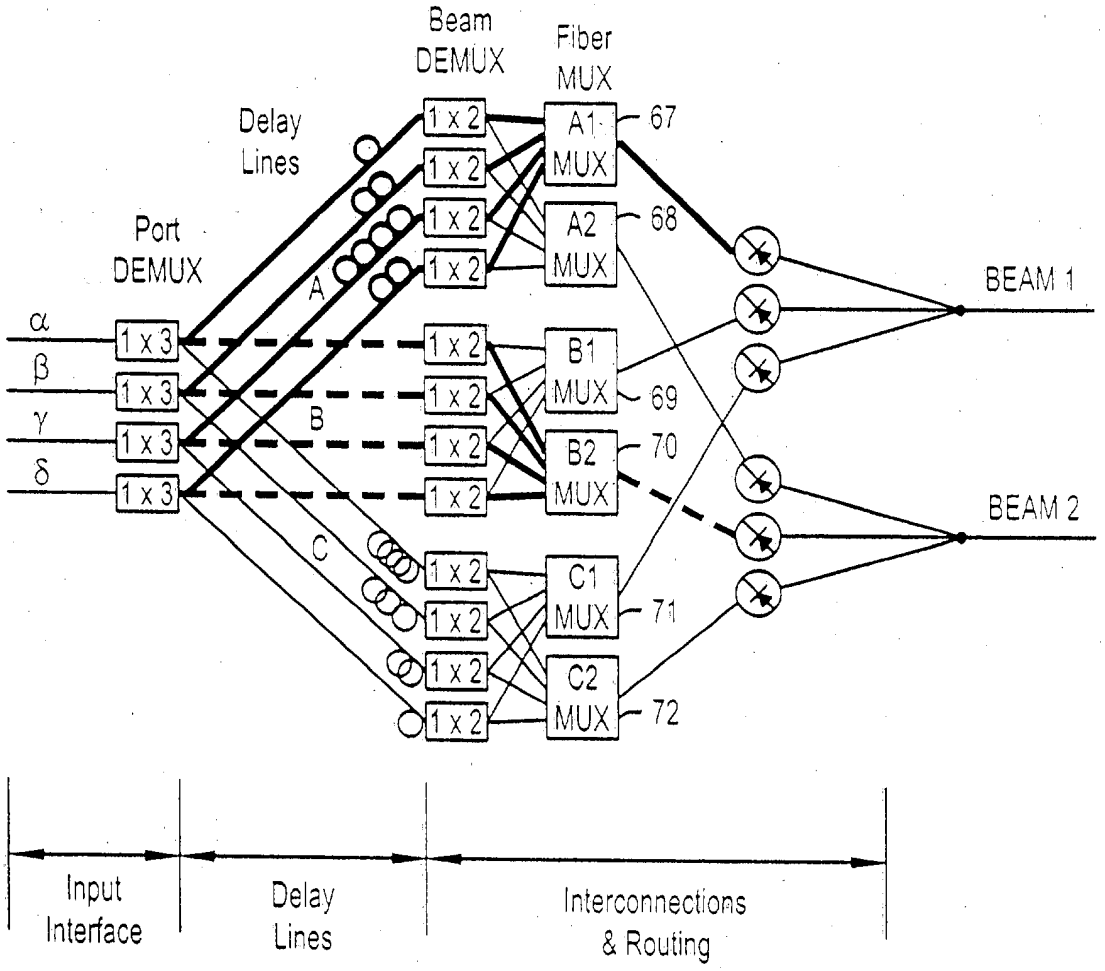
Beam
DEMUX
Fiber
MUX
Delay
Lines
Port
DEMUX
A
B
C
α
β
γ
δ
1 x 3
1 x 2
A1
MUX
A2
MUX
B1
MUX
B2
MUX
C1
MUX
C2
MUX
67
68
69
70
71
72
BEAM 1
BEAM 2
Input
Interface
Delay
Lines
Interconnections
& Routing

Figure 10

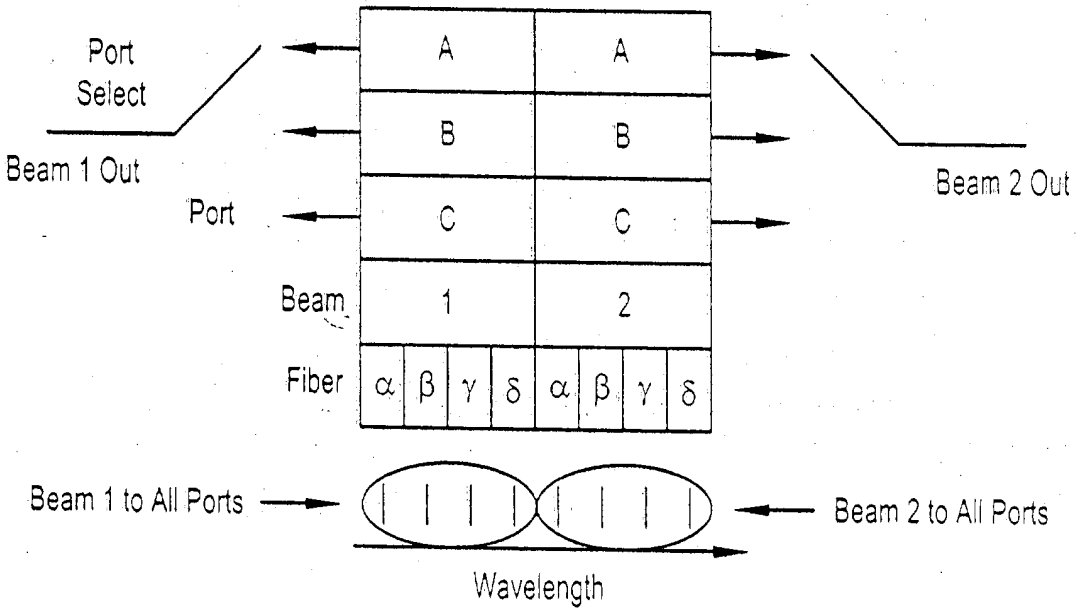
Port
Select
Beam 1 Out
Port
Beam
Fiber
A
A
B
B
C
C
1
2
α β γ δ α β γ δ
Beam 2 Out
Beam 1 to All Ports
Beam 2 to All Ports
Wavelength

Figure 11

Fiber Connections in 2-D Network Switched Delay Lines
(Fiber Rotman Lens)

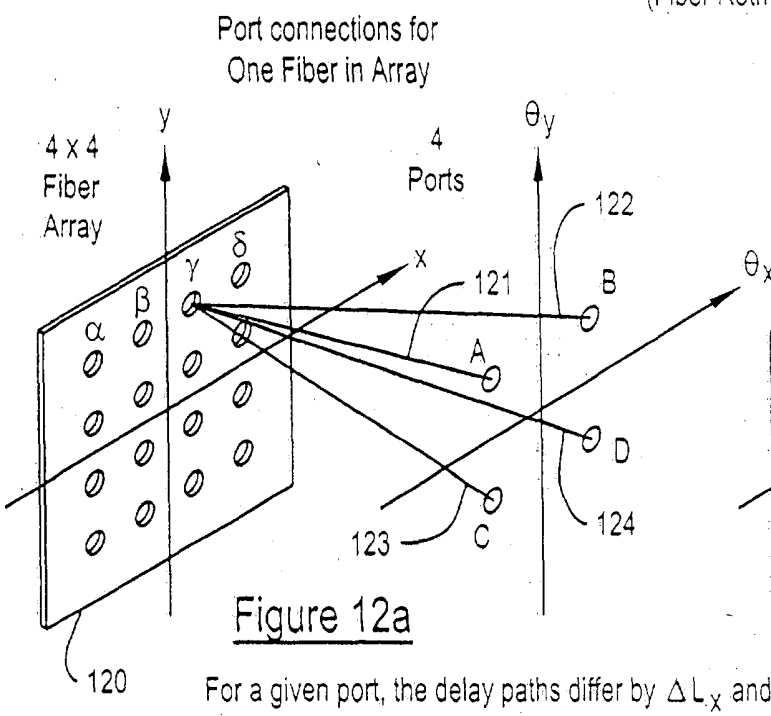

Figure 12a

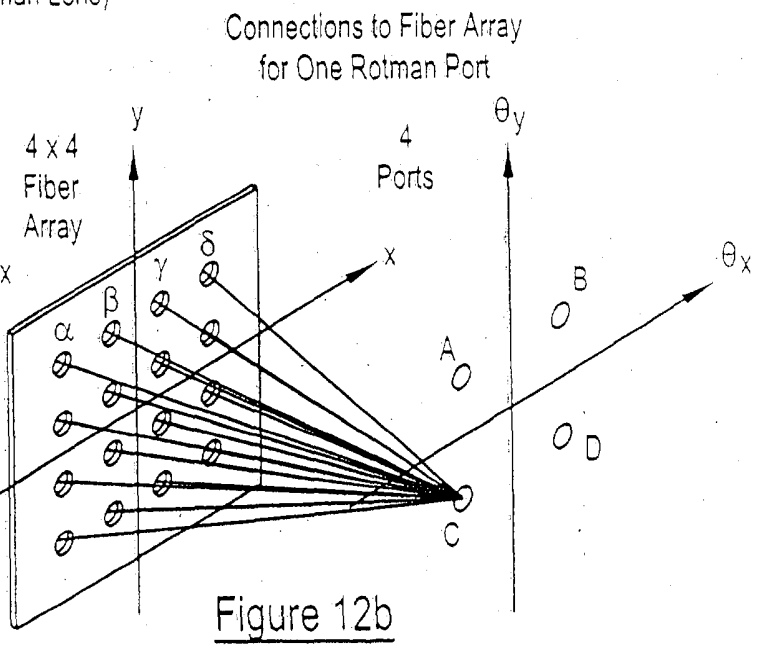

Figure 12b

For a given port, the delay paths differ by ΔL_x and ΔL_y while passing from fiber to fiber in the array

$\Delta L_x = (Dv/c)\sin\theta_x$, $\Delta L_y = (Dv/c)\sin\theta_y$,
D = Antenna element spacing
v = Light velocity in delay line
c = Light velocity in vacuum
θ_x, θ_y = x, y components of delay line scan angle

125

Figure 12

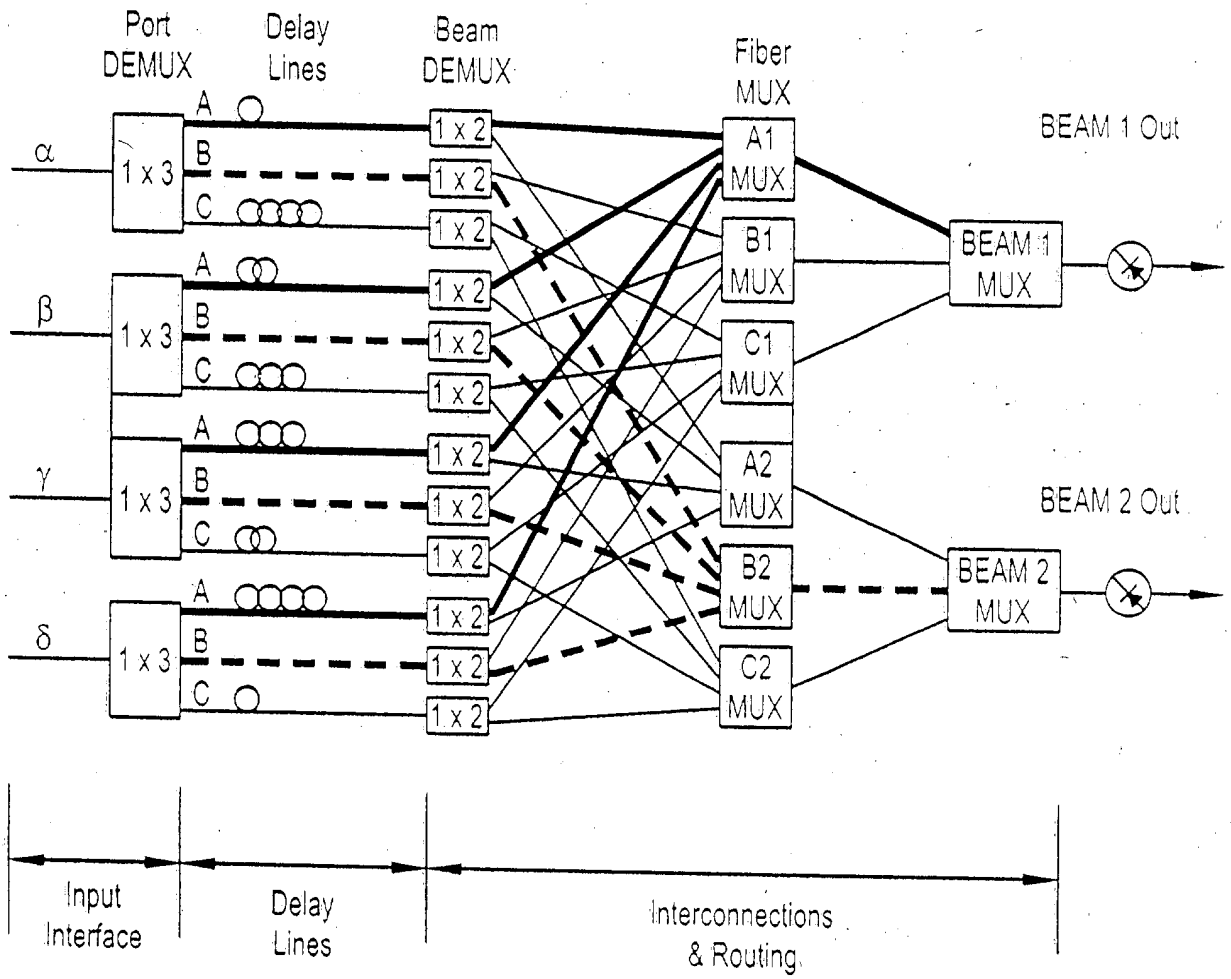
Port DEMUX
Delay Lines
Beam DEMUX
Fiber MUX
α
β
γ
δ
1 x 3
A
B
C
1 x 2
A1 MUX
B1 MUX
C1 MUX
A2 MUX
B2 MUX
C2 MUX
BEAM 1 MUX
BEAM 2 MUX
BEAM 1 Out
BEAM 2 Out
Input Interface
Delay Lines
Interconnections & Routing

Figure 13

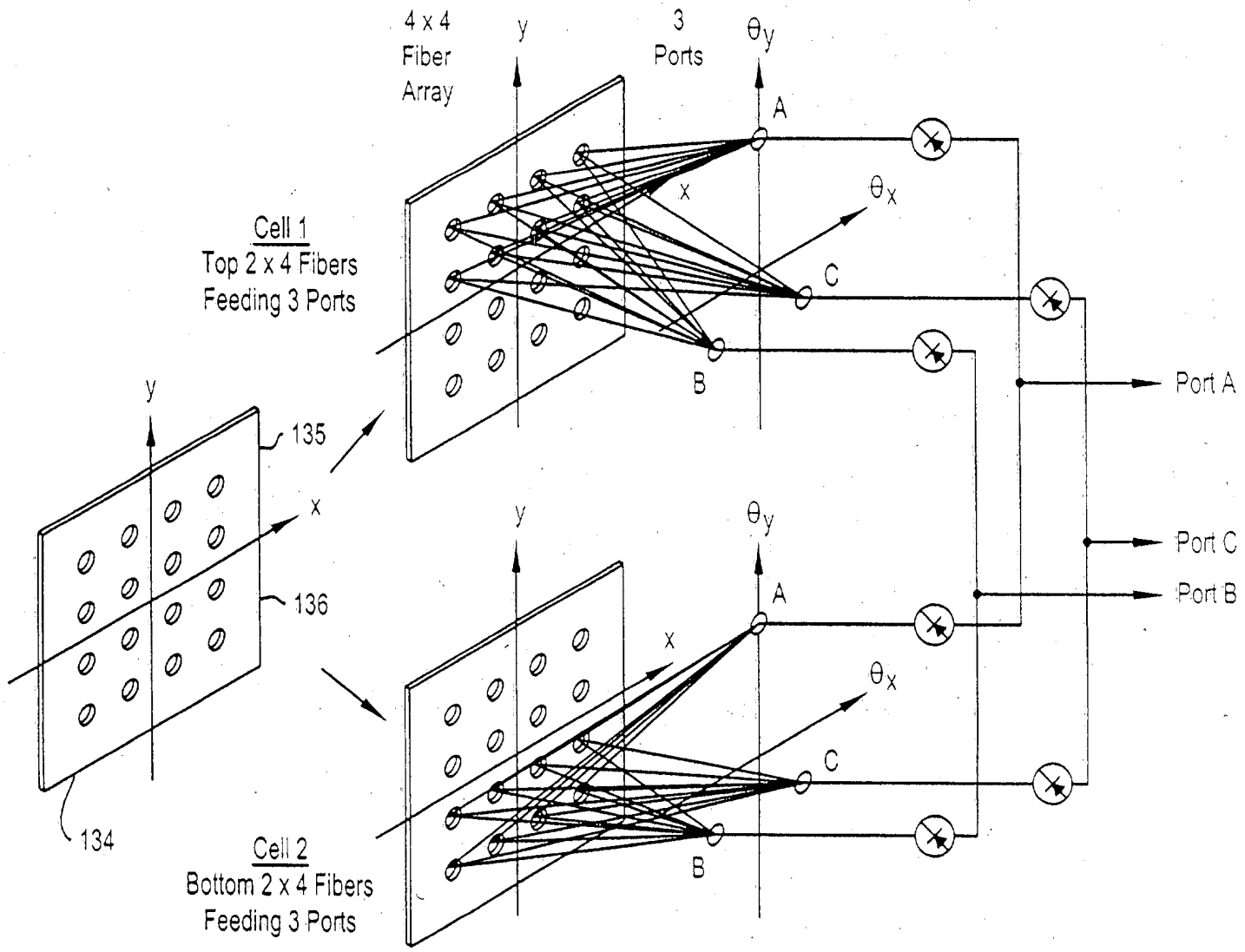
4 x 4
Fiber
Array
y
3
Ports
θ_y
A
x
θ_x
C
B
Cell 1
Top 2 x 4 Fibers
Feeding 3 Ports
y
135
x
136
134
Cell 2
Bottom 2 x 4 Fibers
Feeding 3 Ports
Port A
Port C
Port B

Figure 14

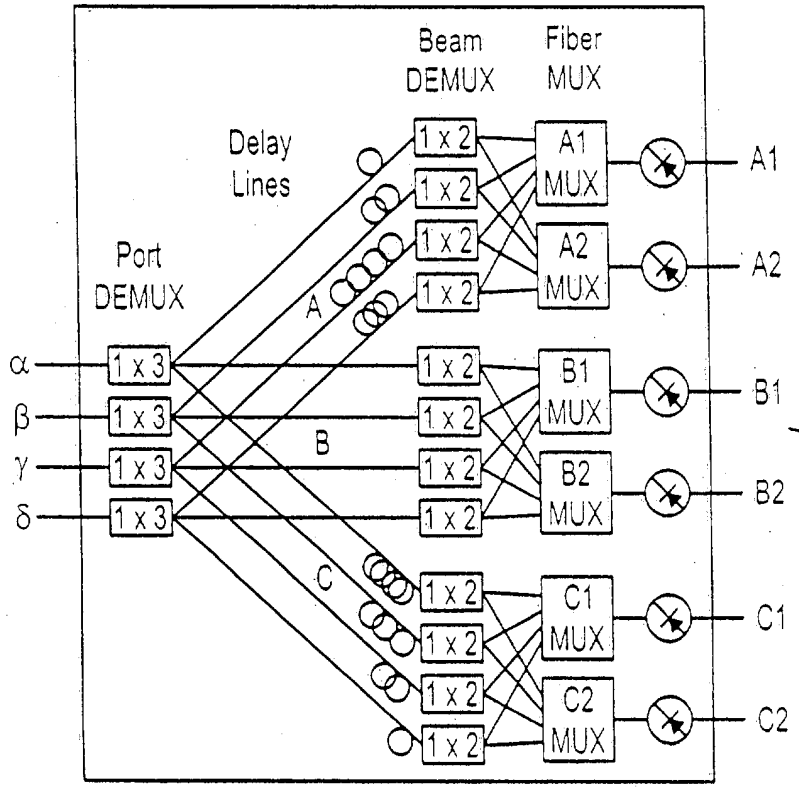

Figure 15a

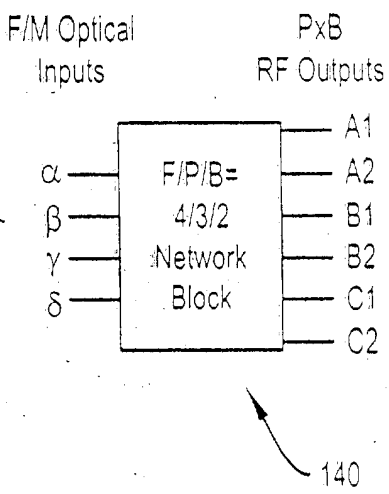

Figure 15b

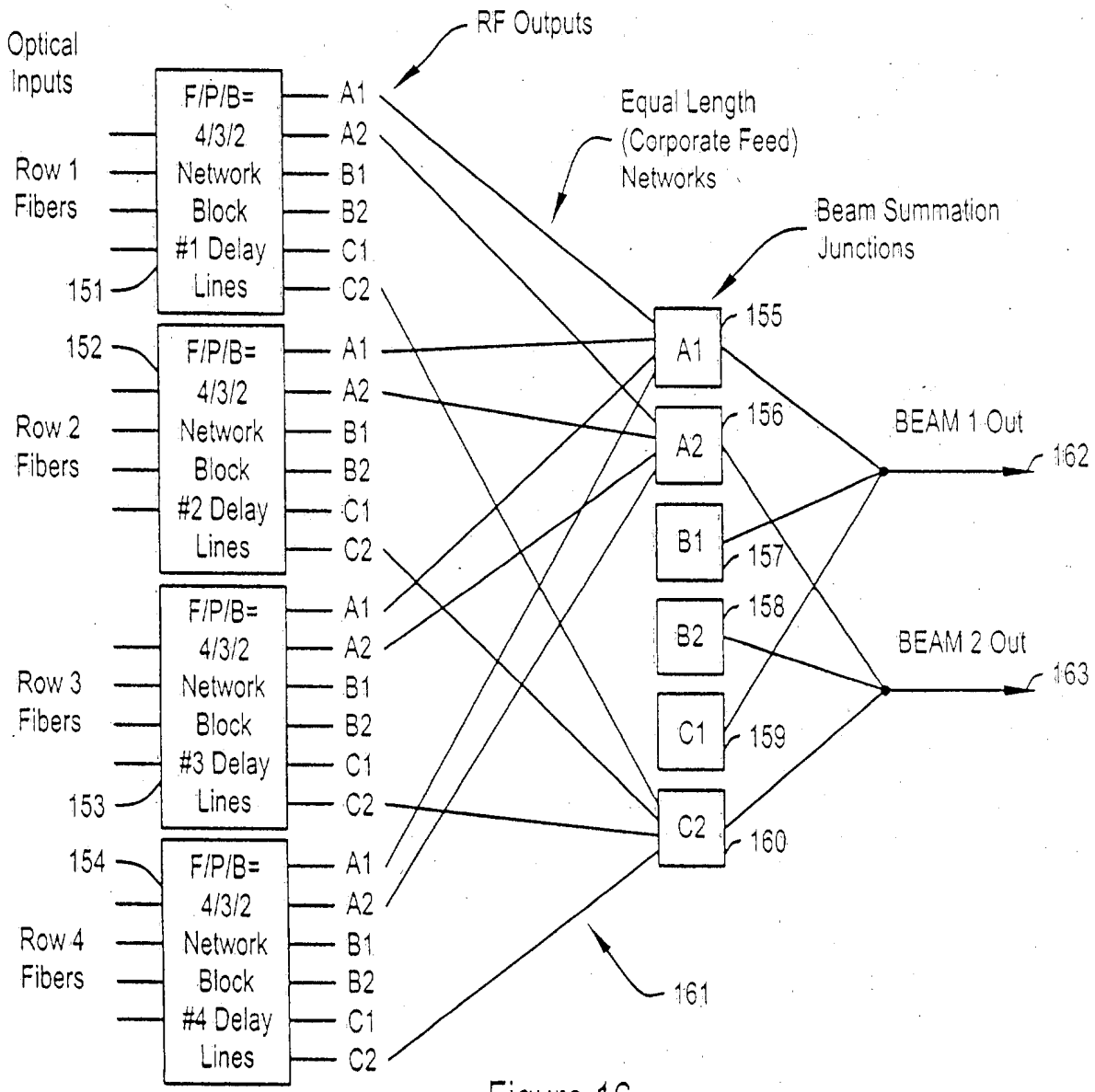
Optical Inputs
Row 1 Fibers
Row 2 Fibers
Row 3 Fibers
Row 4 Fibers
151
152
153
154
F/P/B= 4/3/2 Network Block #1 Delay Lines
F/P/B= 4/3/2 Network Block #2 Delay Lines
F/P/B= 4/3/2 Network Block #3 Delay Lines
F/P/B= 4/3/2 Network Block #4 Delay Lines
A1
A2
B1
B2
C1
C2
RF Outputs
Equal Length (Corporate Feed) Networks
Beam Summation Junctions
155
156
157
158
159
160
161
BEAM 1 Out
162
BEAM 2 Out
163

Figure 16

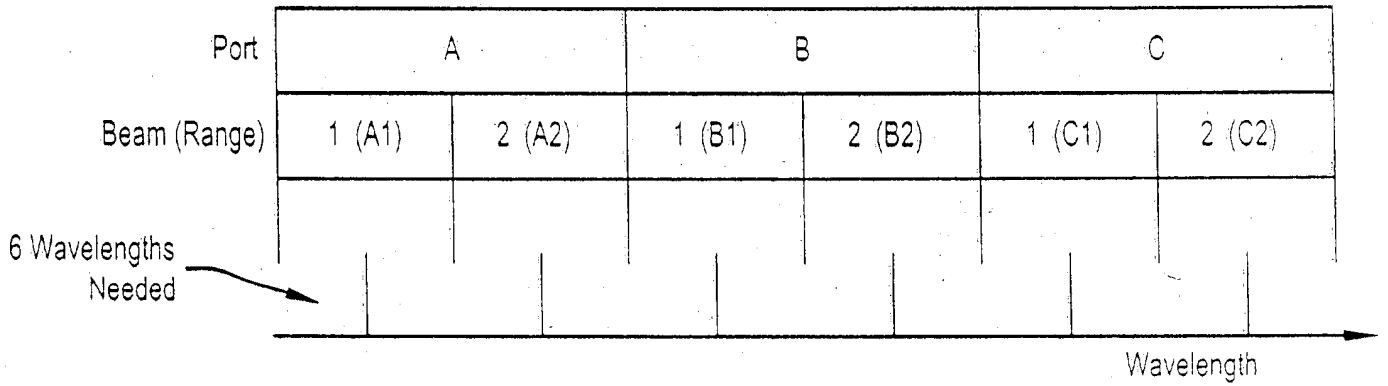
Port
A
B
C
Beam (Range)
1 (A1)
2 (A2)
1 (B1)
2 (B2)
1 (C1)
2 (C2)
6 Wavelengths Needed
Wavelength

Figure 17

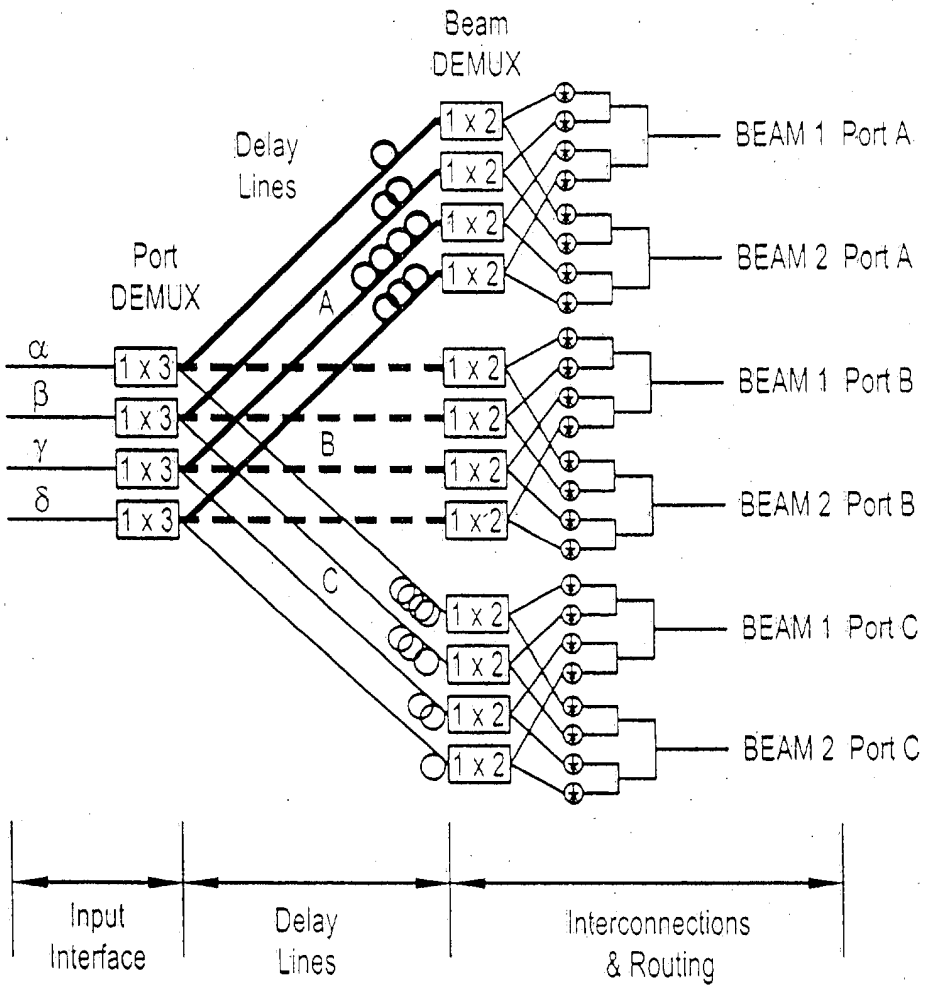
Beam
DEMUX
Delay
Lines
Port
DEMUX
A
B
C
α
β
γ
δ
1 x 3
1 x 2
BEAM 1 Port A
BEAM 2 Port A
BEAM 1 Port B
BEAM 2 Port B
BEAM 1 Port C
BEAM 2 Port C
Input
Interface
Delay
Lines
Interconnections
& Routing

Figure 18

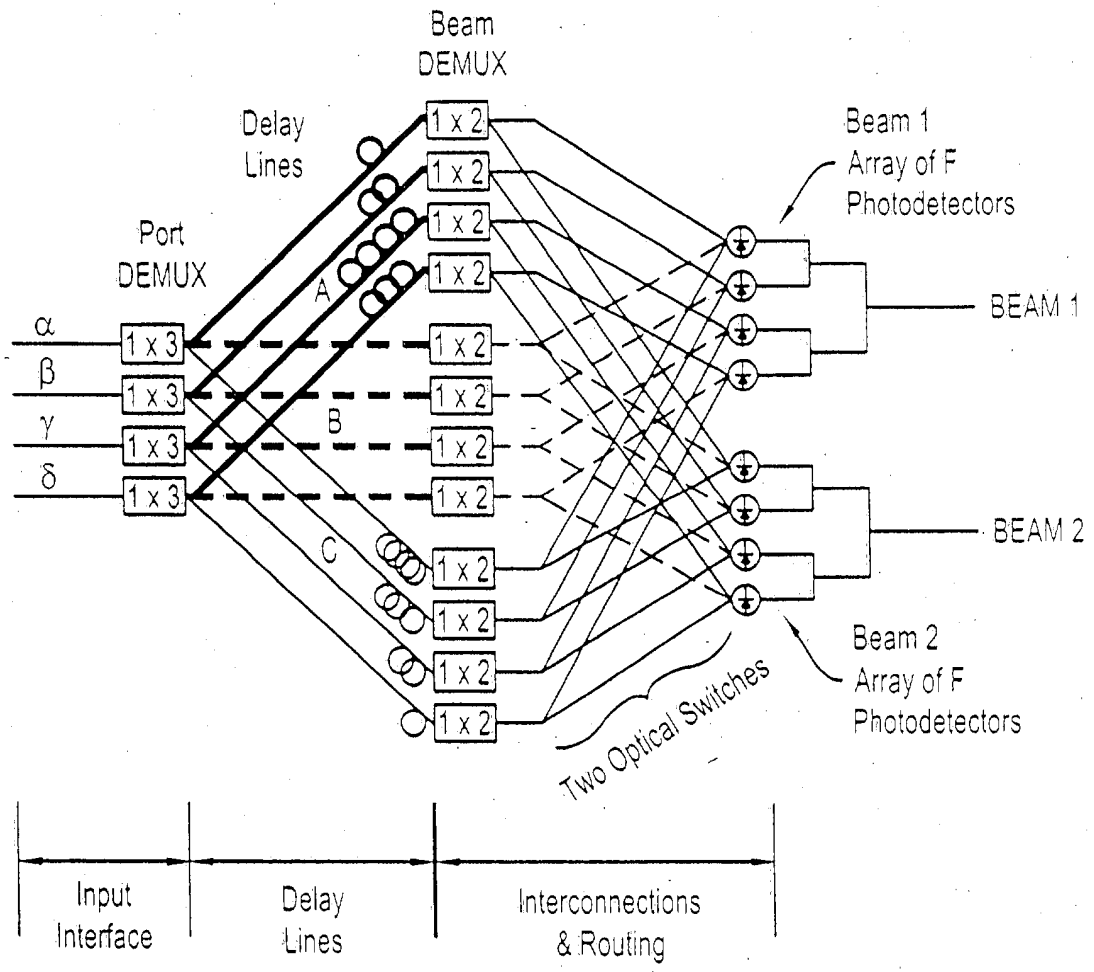
Beam
DEMUX
Delay
Lines
Port
DEMUX
Beam 1
Array of F
Photodetectors
α
β
γ
δ
1 x 3
1 x 2
A
B
C
BEAM 1
BEAM 2
Beam 2
Array of F
Photodetectors
Two Optical Switches
Input
Interface
Delay
Lines
Interconnections
& Routing

Figure 19